

Section 9. LCD Display

Freescal Embedded GUI and TWR-LCD

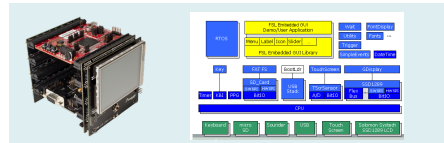
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Module Objectives

- ▶ This session will introduce you to the..
 - Features of the new TWR-LCD Module
 - Freescal Graphic Library Solution for Embedded MCU's
 - Documentation and Demo Software available.



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Agenda

- ▶ Introduction
- ▶ TWR-LCD System
- ▶ Freescal Embedded GUI (D4D)
- ▶ Demo Projects
- ▶ Third Party Software Solutions
- ▶ Demonstration Labs with Codewarrior for MCU V10
- ▶ Additional Resources
- ▶ Review

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Introduction

- ▶ Driving graphics LCD panels normally requires a dedicated MPU
- ▶ Solutions such as the Coldfire MCF532x, MCF5227x or i.MX devices have been specifically designed for this purpose
- ▶ Recently, a number of new LCD displays have been released to the market which have LCD controllers integrated onto the LCD glass
- ▶ A simple SPI or 8/16 bit parallel interface can be driven by any microcontroller

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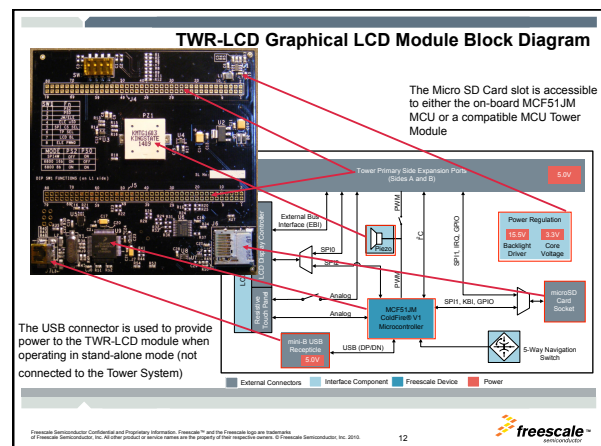
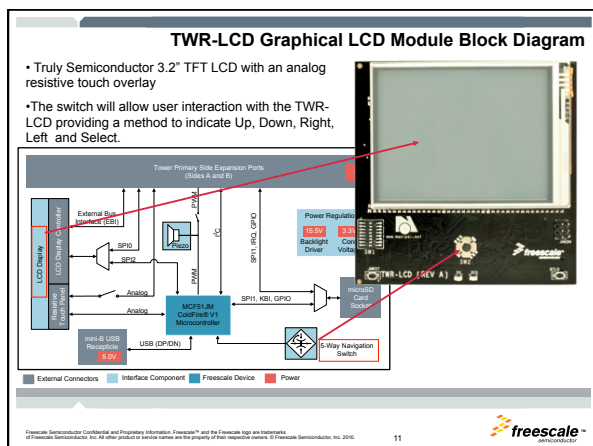
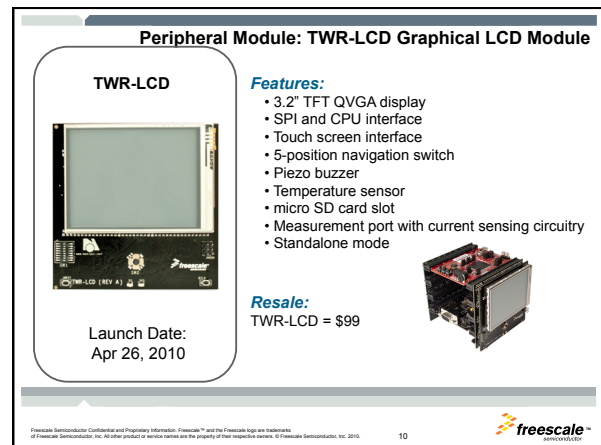
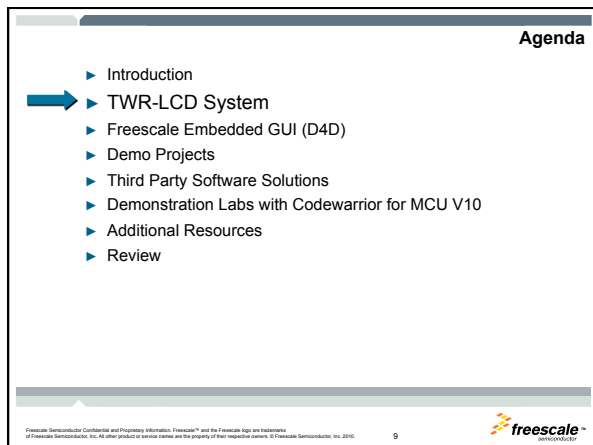
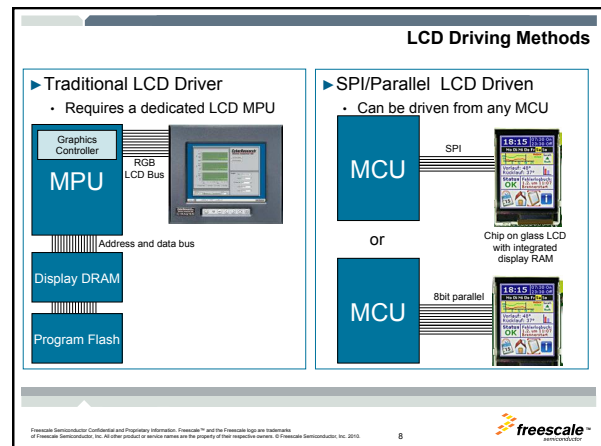
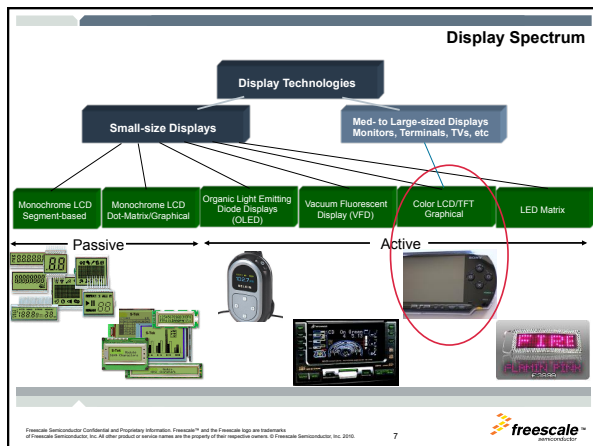


Smart vs Dumb LCD Panels & Bus requirements

- ▶ Dumb LCD TFT panels are very much like DRAM's
 - ❑ No on-board frame buffer or graphics engine
 - ❑ Cell's need to be refreshed periodically
 - ❑ Refreshing uses a lot of bus bandwidth
 - ❑ Cheaper but require LCD controller
- ▶ Smart LCD TFT panels – Like Static RAM
 - ❑ LCD is refreshed from on-board RAM
 - ❑ CPU bus bandwidth is only used when data must be changed
 - ❑ Requires significantly less CPU bus bandwidth
 - ❑ More expensive but does not require LCD controller

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- ▶ **Freescal Embedded GUI (D4D)**
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What's the Freescal Embedded GUI?

- ▶ High level object graphic driver for color LCD
- ▶ Structure of driver brings complete SW solution for applications with LCD screen
- ▶ Touch screen capability
- ▶ Organization done by screen with objects
- ▶ We can find the Alias references to **D4D** (Driver for Display) in function software

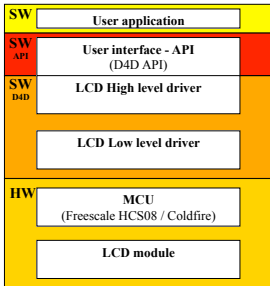


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Block scheme of FGUI implementation

- ▶ User application – layer of user application code
- ▶ Application programmable interface - interface layer between user application and FGUI
- ▶ D4D high level - layer that manage all screens and objects (redraws, input keys, touch screen events etc.)
- ▶ LCD low level – manage communication with LCD and provides some basic function (Draw line, bitmap, circle etc.)
- ▶ HW – Freescal MCU board + LCD



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Features of Freescal Embedded GUI

- ▶ Multiple platform support. Tested on HCS08/MCF51– Flexis series 8-, 32-bit MCUs and MCF52xx
- ▶ Objects:
 - Button
 - Check Box / User handled Radio Button
 - Gauge
 - Icon
 - Label
 - Menu
 - Picture
 - Slider
 - Graph

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Freescal Embedded GUI Screen

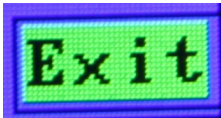
- ▶ The basic item of FGUI structure is SCREEN
- ▶ **The screen representing the real screen showed on LCD**
- ▶ The screen definition contains:
 - list of all used objects on screen
 - function bodies:
 - OnInit
 - OnActivate
 - OnDeactivate
 - OnMain
 - OnObjectMsg

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Freescal Embedded GUI Button Object

- ▶ Button object is targeted for control of user functions



- ▶ Check Box object is targeted for control and set up of user application



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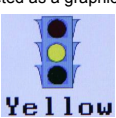
Freescal Embedded GUI Gauge Object

- Gauge object is targeted as a graphic information of numerical values



Value: 71

- Icon object is targeted as a graphic information



Yellow

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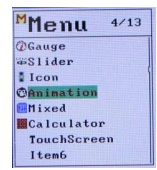
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Freescal Embedded GUI Label object

- Label object is targeted as a text information



- Menu object is targeted as a control item



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Freescal Embedded GUI Picture object

- Picture object is used only to draw bitmap on screen

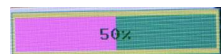


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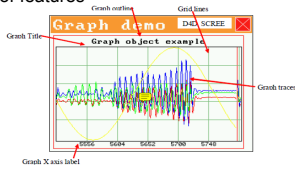
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Freescal Embedded GUI Slider object

- Slider object is targeted as a graphic information of numerical values and for setting this numerical values



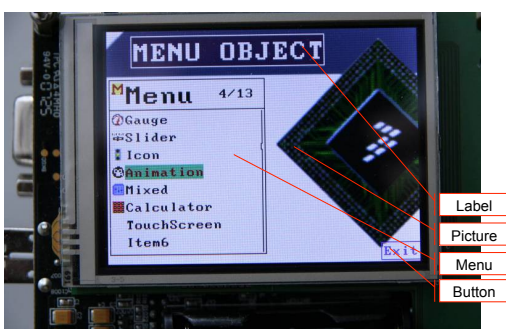
The D4D_GRAPH object is prepared to create a simple graph that provides a lot of features



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Freescal Embedded GUI example application Screen Shot



Label
Picture
Menu
Button

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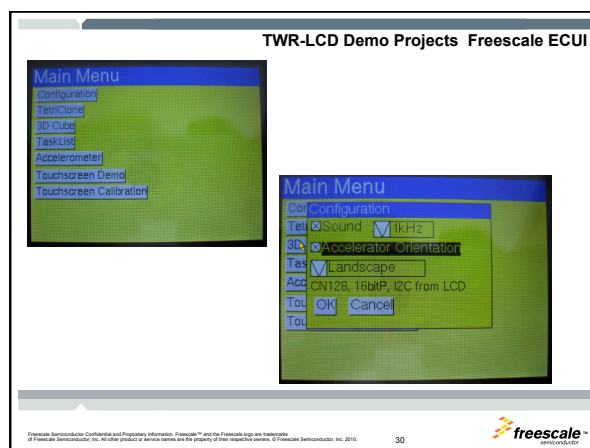
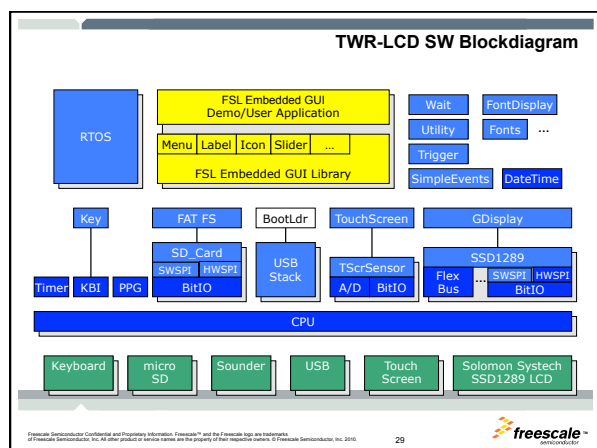
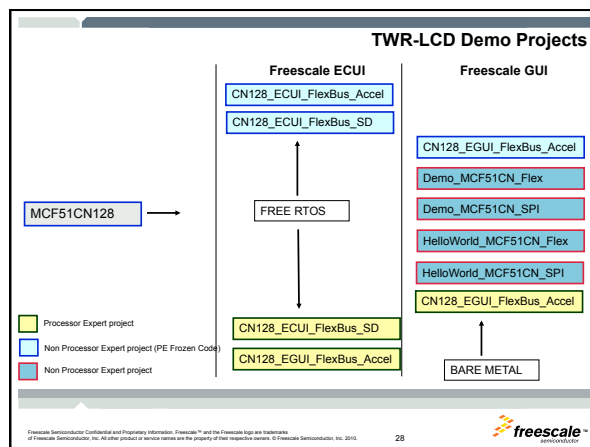
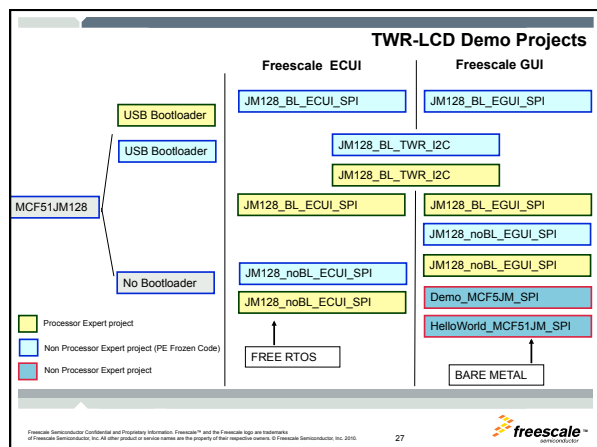
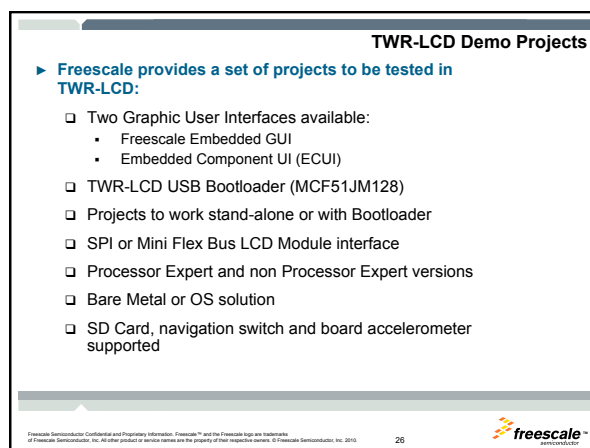
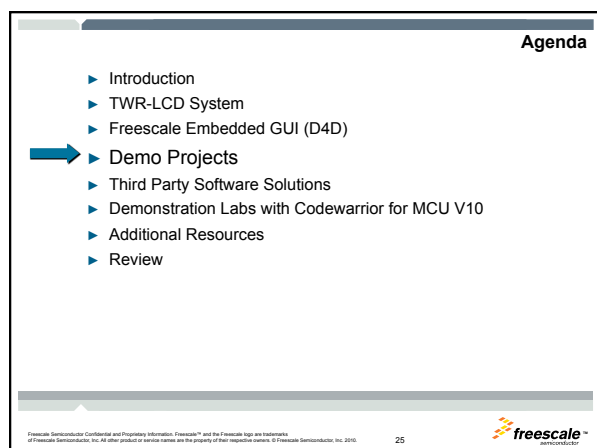
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Freescal Embedded GUI example application Window



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UserInterface

Encapsulation of User Interface Widgets

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Freescall Embedded GUI Converter Utility

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TWR-LCD Third Party Software Solutions

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Segger emWIN

- emWIN is designed to provide an efficient, processor- and display controller-independent graphical user interface
- It is compatible with single-task and multitask environments.
- emWIN is shipped as C source code
- It may be adapted to any size physical and virtual display with any display controller and CPU

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Swell Peg

- C/PEG is a complete graphics solution for embedded developers written entirely in ANSI C.
- C/PEG provides optimized graphics primitives, text and bitmap drawing and supports higher level graphic objects.
- C/PEG works in concert with many industry standard real time operating systems from the leading vendors.
- C/PEG is delivered with full source code, complete documentation, a long list of example programs and hardware interface support.

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Freescale Embedded GUI + TWR-LCD Demo Labs “Codewarrior for MCU V10”

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Demo Labs

▶ TWR-LCD projects for CodeWarrior for MCU v10:

- ▶ Demo_MCF51CN_Flex
- ▶ Demo_MCF51CN_SPI
- ▶ Demo_MCF51JM_SPI
- ▶ HelloWorld_MCF51CN_Flex
- ▶ HelloWorld_MCF51CN_SPI
- ▶ HelloWorld_MCF51JM_SPI
- ▶ HelloWorld_MCF51JM_SPI_BL
- ▶ JM128_BL_ECUI
- ▶ JM128_Bootloader

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Demo Labs

- ▶ Lab1 : Demo Application programming using Bootloader
- ▶ Lab2 : HelloWorld Application

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Lab1 : Demo Application programming using Bootloader

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Lab1 : Demo Application programming using Bootloader

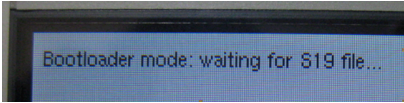
▶ Connect USB cable to TWR-LCD

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Lab1 : Demo Application programming using Bootloader

- ▶ The TWR-LCD features a bootloader to facilitate the loading of applications without the need for an external debugger.
- ▶ Bootloader will enumerate the TWR-LCD JM128 as a MSD (Mass Storage Device).
- ▶ To enter the bootloader hold the 'BTLD' button while momentarily pressing the 'JMRST' button and finally releasing 'BTLD'.
- ▶ In bootloader mode, you will hear a beep from the sounder and the screen will write a welcome message.



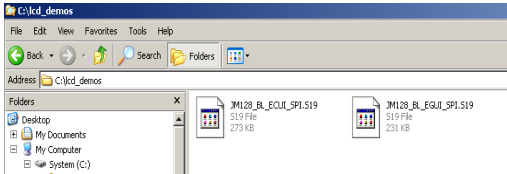
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Lab1: Demo Applications Programming

▶ Precompiled Applications:



▶ Now you can drag&drop / copy S19 (Motorola S-Records) precompiled applications files to the bootloader

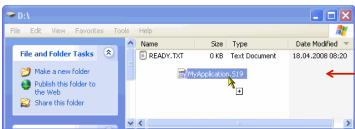
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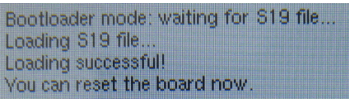
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Lab1: Demo Applications Programming

▶ Drag&Drop S19 Demo file to bootloader



▶ The bootloader will load the file and flash the application



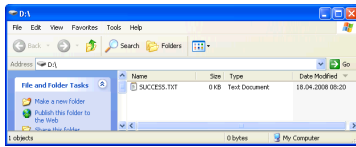
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Lab1: Demo Applications Programming

▶ Additionally the MSD (Mass storage device will show 'SUCCESS.TXT')



▶ Now you can reset the board (pressing JMRST), and this will launch your new application

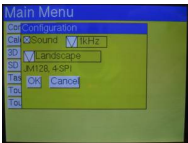
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Lab1: Demo Applications Programming

▶ Flash and Explore the Applications:



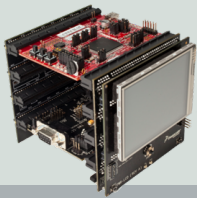

If an application is already loaded, then you need to reset the board (press the JMRST button) while holding down the BTLD button

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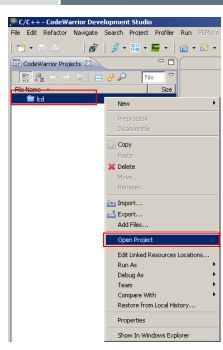
Lab2 : HelloWorld Application




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Lab2 : HelloWorld Application



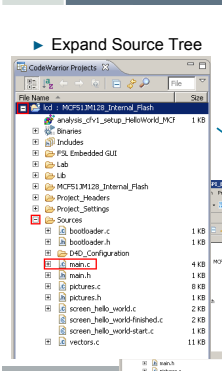
- ▶ Select **lcd** Project
- ▶ Right click -> Open Project

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Lab2 : HelloWorld Application

▶ Expand Source Tree



▶ Open **main.c** (Double click)

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Lab2 : HelloWorld Application

```
// Main Loop
void main(void) {
    BL_RedirectUserVectors();
    MCU_Init(); // MCU Initialization Clock, Watchdog etc
    Timer_Init(); // Periodic Timer interrupt initialization - 25ms

    D4D_Init(&screen_hello_world); // Init HelloWorld Screen
    D4D_SetOrientation(D4D_ORIENT_LANDSCAPE);

    EnableInterrupts; /* enable interrupts */

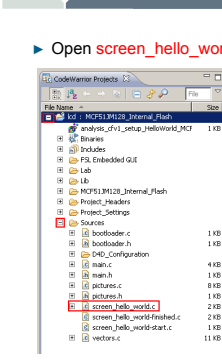
    for(;;) {
        D4D_Poll(); // D4D poll loop // Library Polling Routine
        RESET_WATCHDOG(); /* feeds the dog */
    } /* loop forever */
    /* please make sure that you never leave main */
}
```

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Lab2 : HelloWorld Application

▶ Open **screen_hello_world.c**

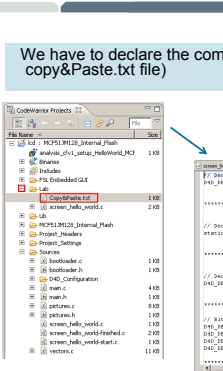


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Lab2 : HelloWorld Application

We have to declare the components in our screen (write code or use copy&Paste.txt file)



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Lab2 : HelloWorld Application

Write code under "INCLUDE YOUR DECLARATION CODE HERE"

- ▶ Label Declaration:


```
D4D_DECLARE_STD_LABEL_AUTOSIZE(lbl_HelloWorld, "Hello World", 70, 10, FONT_8x14_BIG)
```
- ▶ Text Button Declaration:


```
D4D_DECLARE_TXT_BUTTON_AUTOSIZE(btn_Example, "Change Icon", 70, 100, FONT_8x14_BIG, OnClick_BtnExample)
```
- ▶ BitMaps:


```
D4D_DECLARE_BITMAP(bmpIconGraph, icon_graph24x24, NULL)
D4D_DECLARE_BITMAP(bmpIconBulb, icon_bulb24x24, NULL)
D4D_DECLARE_BITMAP(bmpIconPaint, icon_paint24x24, NULL)
D4D_DECLARE_BITMAP(bmpIconTchScr, icon_Touchscreen24x24, NULL)
```

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Lab2 : HelloWorld Application

- Icon with 4 bitmaps Declaration:


```
D4D_DECLARE_STD_ICON_BEGIN_AUTOSIZE(icon_Example, "icon", 120, 150, FONT_8x14, NULL)
D4D_DECLARE_ICON_BITMAP(&bmpIconGraph)
D4D_DECLARE_ICON_BITMAP(&bmpIconBulb)
D4D_DECLARE_ICON_BITMAP(&bmpIconPaint)
D4D_DECLARE_ICON_BITMAP(&bmpIconTchScr)
D4D_DECLARE_ICON_END()
```
- Screen with 3 objects Declaration:


```
D4D_DECLARE_STD_SCREEN_BEGIN(screen_HelloWorld, ScreenHelloWorld_)
D4D_DECLARE_SCREEN_OBJECT(tbl_HelloWorld)
D4D_DECLARE_SCREEN_OBJECT(btn_Example)
D4D_DECLARE_SCREEN_OBJECT(icon_Example)
D4D_DECLARE_SCREEN_END()
```

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Lab2 : HelloWorld Application

We have to add the callback function code for Button Touch/Click event under "INCLUDE YOUR BUTTON CALLBACK CODE HERE"

```
D4D_UNUSED(pThis);
D4D_IconChangeIndex(&icon_Example, 1);

static void OnClick_BtnExample(D4D_OBJECT* pThis)
{
    D4D_UNUSED(pThis);
    D4D_IconChangeIndex(&icon_Example, 1);
}
```

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Lab2 : HelloWorld Application

- Build Application

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Lab2 : HelloWorld Application

- Find the S19 application output file :
C:\CW10\workspace\lcd\MCF51JM128_Internal_Flash\HelloWorld_MCF51JM_SPI_BL.elf

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Lab2 : HelloWorld Application

- Connect USB cable to TWR-LCD

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Lab2 : HelloWorld Application

- Drag&Drop S19 output file to bootloader Drive

The bootloader will load the file and flash the application

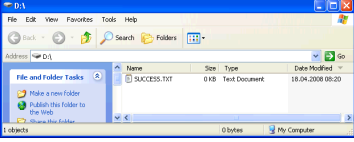
```
Bootloader mode: waiting for S19 file...
Loading S19 file...
Loading successful!
You can reset the board now.
```

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Lab2 : HelloWorld Application

- ▶ Additionally the MSD (Mass storage device will show 'SUCCESS.TXT')



- ▶ Now you can reset the board (pressing JMRST), and this will launch your HelloWorld Application

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Lab2 : HelloWorld Application

- ▶ Touch the Button to change the icon image.



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Agenda

- ▶ Introduction
- ▶ TWR-LCD System
- ▶ Freescal Embedded GUI (D4D)
- ▶ Demo Projects
- ▶ Third Party Software Solutions
- ▶ Demonstration Labs with Codewarrior for MCU V10
- ▶ Additional Resources
- ▶ Review

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TWR-LCD Documentation

- ▶ TWR-LCD User Manual
- ▶ TWR-LCD Lab Guide
- ▶ Freescal_Embedded_GUI_User_Manual
- ▶ TWR-LCD-RevA-SCH : TWR-LCD Schematic
- ▶ TWR_LCD_QSG : TWR-LCD Quick Star Guide
- ▶ SSD1289 : Display Controller Datasheet
- ▶ TRULY-TFT2N0369-E : Truly Display Datasheet

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Review

- ▶ Many LCD displays with controller integrated have been released to the market
- ▶ TWR-LCD Graphical LCD Module enables fast design across different Freescal devices
- ▶ Freescal Embedded GUI provide High level object graphic driver for color LCD's
- ▶ Freescal Embededd GUI and TWR-LCD reduce Time to market for Low End Graphic Applications

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BACKUP SLIDES

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Board Set up

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TWR-LCD setup for Standalone

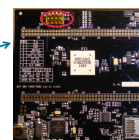
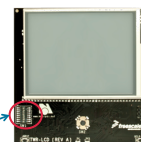
► TWR-LCD Settings

• This configuration is using the TWR-LCD JM128 CPU to drive the TWR-LCD.

• TRW-LCD SW1 settings:

- 1: OFF (PS2)
- 2: ON (PS1)
- 3: OFF (JM_ELE)
- 4: OFF (EuSD)
- 5: ON (SPI_SEL)
- 6: OFF (TP_SEL)
- 7: ON (BL_CNTRL)
- 8: OFF (ELE_PWM0)

• TRW-LCD SW5: all OFF



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Flashing Bootloader

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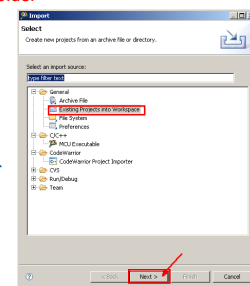
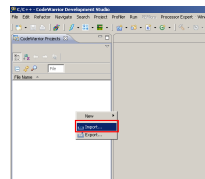


Lab's Software Setup

► Unzip TWR-LCD-Code.zip in any Folder

► Open CW for MCU v10

► Import into Workspace



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Lab's Software Setup

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Lab's Software Setup

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Flashing Bootloader

- ▶ Select JM128_Bootloader project.
- ▶ Right click -> Open Project

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Flashing Bootloader

- ▶ Build Bootloader
- ▶ See Output

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Flashing Bootloader

- ▶ Connect PC to USB Multilink
- ▶ Connect USB cable to TWR-LCD

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Flashing Bootloader

- ▶ BDM and COM port drivers Installation

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Flashing Bootloader

- ▶ Right click -> Properties
- ▶ Select "Run/Debug Settings"
- ▶ Select "JM128_Bootloader - MCF51JM128_Internal_Flash - PnE USB BDM"
- ▶ Click "Edit"

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Flashing Bootloader

- ▶ Select Tab "Debugger"
- ▶ Select Tab "Connection"
- ▶ Select Connection: P&E Coldfire V1 Multilink
- ▶ Select Interface: USB Multilink
- ▶ Click Refresh

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Flashing Bootloader

- ▶ Click Apply
- ▶ Click OK
- ▶ Click OK

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Flashing Bootloader

- ▶ Click Debug

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Flashing Bootloader

- ▶ Click Resume (F8)

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Flashing Bootloader

- ▶ New Device JM128 will be detected and New Drive created
- ▶ TWR-LCD Display shows the Bootloader screen

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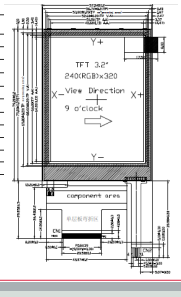
TWR-LCD Configuration

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TWR-LCD Graphical LCD Module – TFT Display features

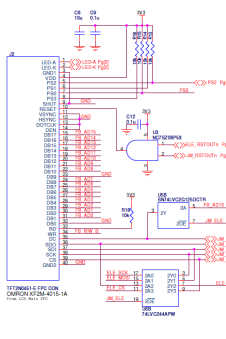
TRULY TFT2N0369-E Features:

Item	Contrasts
LCD type	TFT TRANSMISSIVE
Viewing direction	9:00
Module area (W × H)	57.54 × 79.20
Viewing area (W×H)	52.60 × 68.60(TP)
Active area (W×H)	48.60 × 64.80
Number of Dots	240 (RGB) × 320
Driver IC	SSD1289
Backlight Type	LED
Module Power consumption	268
Interface Type	System parallel / RGB interface
Input voltage	3.0



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TWR-LCD Graphical LCD Module – ColdFire Mini Flex Bus Connection



PS	PS1	PS2	Interface Mode	Data bus
0	1	1	3-wire SPI	
1	1	1	4-wire SPI	
1	0	1	24-bit 6800 parallel interface	D[1:10], D[8:1]
1	0	0	8-bit 6800 parallel interface	D[8:1]
1	0	0	16-bit 6800 parallel interface	D[1:10], D[8:1]
1	0	0	8-bit 6800 parallel interface	D[8:1]
0	1	1	24-bit 6800 parallel interface	D[1:10]
0	1	0	8-bit 6800 parallel interface	D[8:0]
0	1	0	16-bit 6800 parallel interface	D[1:10]
0	1	0	8-bit 6800 parallel interface	D[8:0]
0	0	1	Reserved	Reserved
0	0	1	Reserved	Reserved
0	0	1	16-bit 6800 parallel interface + 4-wire SPI	D[1:10]

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TWR-LCD Graphical LCD Module – SW1 Configuration

Display Driver MCU Selection

JM1ELE (SW1-DIP3)	ON	Enables SPI connection from SPI0 of Primary Elevator Connector
OFF	Enables SPI connection from on-board MCF51JM MCU	

Tower MCU SPI CS Selection

SPI CS SEL (SW1-DIP6)	ON	Select SPI0 CS1 as the chip-select for LCD SPI interface
OFF	Select SPI0 CS0 as the chip-select for LCD SPI interface	

LCD Communication Mode Settings

SW1-DIP1 (PS2)	SW1-DIP2 (PS0)	Description
OFF	ON	Enables SPI communication mode to the LCD Display; can be driven by SPI0 on the Primary Elevator or by the on-board MCF51JM, selectable by JM1ELE (SW1-DIP3)
ON	OFF	Enables EBI (16b mode) communication to the LCD Display. This interface is only accessible from the Tower Elevator MCU
ON	ON	Enables EBI (8b mode) communication to the LCD Display. This interface is only accessible from the Tower Elevator MCU

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TWR-LCD Graphical LCD Module – SW1 Configuration

Resistive Touch MCU Selection

TP SEL (SW1-DIP6)	ON	Disables MCF51JM connection to the LCD Touch Panel. Use SW5 to enable ADC connection from Primary Elevator Connector
OFF	Enables MCF51JM connection to the LCD Touch Panel. Ensure that all switches on SW5 DIP are OFF.	

MicroSD Card Slot MCU Selection

ELE uSD (SW1-DIP4)	ON	MicroSD is connected to the SPI1 of Primary Elevator Connector
OFF	MicroSD is connected to the on-board MCF51JM MCU	

MicroSD Backlight Selection

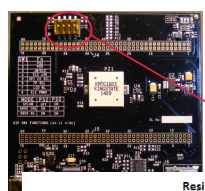
ELE uSD (SW1-DIP7)	ON	Enables LCD Backlight
OFF	Disables LCD Backlight	

Piezo Buzzer Selection

ELE uSD (SW1-DIP8)	ON	Piezo Buzzer is controlled by PWM0 of Primary Elevator Connector and on-board MCF51JM
OFF	Piezo Buzzer is controlled by on-board MCF51JM only	

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TWR-LCD Graphical LCD Module – SW5 Configuration



SW5 enables ADC connection from Primary Elevator Connector

Resistive Touch Analog Isolation Settings

SW5-DIP 1	Touch Panel Isolation (XPLS)	ON	Connects AN4 (TWR-ELEV) to XPLS Touch Panel Signal
	OFF	Disconnects AN4 from Touch Panel	
SW5-DIP 2 <th>Touch Panel Isolation (XMNS)</th> <th>ON</th> <th>Connects AN5 (TWR-ELEV) to XMNS Touch Panel Signal</th>	Touch Panel Isolation (XMNS)	ON	Connects AN5 (TWR-ELEV) to XMNS Touch Panel Signal
	OFF	Disconnects AN5 from Touch Panel	
SW5-DIP 3 <th>Touch Panel Isolation (YMNS)</th> <th>ON</th> <th>Connects AN6 (TWR-ELEV) to YMNS Touch Panel Signal</th>	Touch Panel Isolation (YMNS)	ON	Connects AN6 (TWR-ELEV) to YMNS Touch Panel Signal
	OFF	Disconnects AN6 from Touch Panel	
SW5-DIP 4 <th>Touch Panel Isolation (YPLS)</th> <th>ON</th> <th>Connects AN7 (TWR-ELEV) to YPLS Touch Panel Signal</th>	Touch Panel Isolation (YPLS)	ON	Connects AN7 (TWR-ELEV) to YPLS Touch Panel Signal
	OFF	Disconnects AN7 from Touch Panel	

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